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HELIUM AVAILABILITY ASSESSMENT.(U)
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DEPARTMENT OF THE NAVY
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PA. 18974

AIR VEHICLE TECHNOLOGY DEPARTMENT

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(6) HELIUM AVAILABILITY ASSESSMENT.

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The present supply and demand of helium is discussed. The amount stored in recent years by the Bureau of Mines is given. Predictions of future supply and demand are presented, and the relationship of these predictions to a large lighter-than-air vehicle force is discussed.

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The present supply and demand of helium is discussed. The amount stored in recent years by the Bureau of Mines is given. Predictions of future supply and demand are presented, and the relationship of these predictions to a large lighter-than-air vehicle force is discussed.

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INTRODUCTION

BACKGROUND

The Advanced Navy Vehicles Concept Evaluation (ANVCE) program is considering a variety of candidate vehicles to perform various naval missions in the 1980 to 2000 time period. Lighter-than-Air (LTA) vehicles are among those candidates. Before any serious consideration can be given to LTA vehicles for a future time period, a high level of confidence must be established concerning the availability of a suitable lifting gas during that time period. A study was performed to determine the future availability and technical feasibility of various lifting gases. This memorandum documents an in-house investigation of helium availability.

HELIUM PROPERTIES

Helium is the second-lightest of the elements; only hydrogen is lighter. Helium is chemically inert at all temperatures. This combination of properties makes it the ideal lifting gas for LTA vehicles. The only question which hampers its definite identification as the lifting gas for future generation LTA vehicles relates to its future availability. Although helium is one of the commonest elements in the universe, it is one of the scarcest on the earth.

CURRENT SITUATION

The primary source of helium today is certain natural gasfields in Texas, Oklahoma, and Kansas which contain helium concentrations of approximately 0.3%, which are readily recoverable. Helium liquefies at -269^{o} C, so separation is accomplished by cooling the mixture until all other components liquify. Some other gasfields contain lower concentrations which are not as economical to separate. In addition, the earth's atmosphere contains a very low concentration of helium which can be extracted only at a cost many times that of current extraction from natural gas.

The question of future availability arises because the relatively helium-rich gas fields are being depleted as natural gas is being used for fuel. Helium contained in the burned fuel is lost to the atmosphere. The dissipation of this valuable natural resource led to the passage of the Helium Act Amendment in 1960. A long-range conservation program was established in which the Bureau of Mines of the U. S. Department of the Interior was assigned the responsibility to provide helium for essential government activities by management of the Federal Helium Program. Helium is stored underground at the Cliffside Fields in Amarillo, Texas. The stored helium consists of that extracted by the Bureau of Mines and large quantities purchased under long term contracts from commercial gas suppliers. The purchases were terminated by the government in 1973, and consequent litigation is in progress. The Bureau of Mines is still extracting and storing helium, but commercial suppliers are either not extracting it or are venting their excess to the atmosphere after extraction.

The amount of helium stored as of 1 January 1975 in the Cliffside Fields is 1.084 billion cubic meters (38.3 billion cubic feet); 1.056 billion cubic meters (37.3 billion cubic feet) belong to the government, and 28.2 million cubic meters (1.0 billion cubic feet) are being stored for commercial gas

suppliers (reference (a)). The trend of the increased amount in storage in recent years is shown in Table I. The termination of purchases in late 1973 is evident in the minor increase in the amount stored in 1974.

T A B L E I
QUANTITY STORED BY THE BUREAU OF MINES
(Taken from reference (a))

Million cubic meters
(Million cubic feet)

	1971	1972	1973	1974
Bureau of Mines Conservation Program	895.9 (31,636)	980.7 (34,629)	1051 (37,110)	1056 (37,283)
Private Producer's Accounts	14.9 (527)	28.4 (1002)	30.9 (1091)	28.2 (996)
Total at end of year	910.8 (32,163)	1009.1 (35,631)	1081.9 (38,201)	1084.2 (38,279)

The two basic assumed management policies listed below concerning the future use of the helium stored by the government were encountered during this investigation. Each of these policies and its effect on the government's helium supply will be covered in one of the following sections of this technical memorandum.

1. The first assumed policy is that the stored helium will be used by only federal agencies. This is in agreement with the interpretation of the Department of the Interior that the Helium Act confers upon the Department the responsibility of providing helium only for essential government activities.

2. The second assumed policy is that when the present production capability diminishes the stored helium will be made available by the government to the total market, including government activities and private industry. This basic policy has many alternatives which will be discussed later.

CURRENT USES

Helium is currently used in the following applications:

1. Purging and pressurizing rockets and spacecraft
2. Welding
3. Controlled atmospheres
4. Leak detection
5. Cyrogenics

6. Chromatography

7. Synthetic breathing mixtures

8. Heat transfer

9. Research

10. Lifting gas for balloons

DEVELOPING TECHNOLOGIES

Advanced technologies related to the energy needs of the country are being developed for possible use after the year 2000. Large amounts of helium will be required, but many of the applications will be closed systems which are non-dissipative, and continuing requirements will be only to replace leakage.

Some of these technologies are:

1. Fusion reactors

2. Superconducting power transmission lines

3. Superconducting magnetic energy storage

P O L I C Y A S S U M P T I O N 1

STORED HELIUM RESERVED FOR FEDERAL AGENCIES

FEDERAL AGENCY ESTIMATES

The six major helium-using federal agencies are the Department of Defense (DOD), National Aeronautics and Space Administration (NASA), Energy Research and Development Administration (ERDA), National Weather Service, National Bureau of Standards, and National Science Foundation. In 1975 each of these agencies submitted to the Department of the Interior estimates of their helium requirements until the year 2000. The total predicted helium requirement for these agencies for the time period 1975 to 2000 is 0.175 billion cubic meters (6.2 billion cubic feet), (reference (b)). The amount presently stored by the Bureau of Mines is over six times the amount which would be necessary to meet the needs of essential government activities through the year 2000. Assuming that the Department of the Interior supplies helium from conservation storage to federal agencies only, it is estimated that the presently stored helium will last for over one hundred years.

The projected Department of the Navy requirements, which are part of the Department of Defense estimate submitted to the Department of the Interior, for gaseous helium through the year 2000 are 19.158 million cubic meters (676.5 million cubic feet) as shown in Table II. This projection does not include large LTA vehicle operations.

T A B L E I I

NAVY HELIUM REQUIREMENTS PROJECTION, 1975 THRU 2000

(Taken from reference (c))

Year	Million Cubic Meters	Million Cubic Feet
1975	0.462	16.3
1976	0.541	19.1
1977	0.578	20.4
1978	0.572	20.2
1979	0.643	22.7
1980	0.663	23.4
1981	0.663	23.4
1982	0.663	23.4
1983	0.663	23.4
1984	0.663	23.4
1985	0.725	25.6
1986	0.725	25.6
1987	0.725	25.6
1988	0.725	25.6
1989	0.725	25.6
1990	0.815	28.8
1991	0.815	28.8
1992	0.815	28.8
1993	0.815	28.8
1994	0.815	28.8
1995	0.878	31.0
1996	0.878	31.0
1997	0.878	31.0
1998	0.878	31.0
1999	0.878	31.0
2000	0.957	33.8
TOTAL	19.158	676.5

LTA HELIUM REQUIREMENT PROJECTION

A first-order-of-magnitude estimate of the quantity of helium which would be required for LTA vehicles was made by assuming that there will be a force of 100 vehicles by the year 2000 and that the vehicles will have become operational at a uniform rate between 1980 and 2000. Replacement rate after the year 2000 will be five vehicles per year. It is assumed that each vehicle will have a gas capacity of 0.2832 million cubic meters (10 million cubic feet) and an annual leakage rate of ten percent. Leakage rates varying from 5 to 60 percent are found in the literature; the 10 percent assumed here is felt to be a realistic goal which will be achieveable with developing fabric technology which will have matured by 1980. Initial filling would require a total of 28.3 million cubic meters (1.0 billion cubic feet) of helium for the 100 vehicles. An additional 28.3 million cubic meters (1.0 billion cubic feet) would be required for replenishment of leaked gas during the twenty year period. The annual replenishment rate after the year 2000 would be 2.83 million cubic meters (0.1 billion cubic feet).

OFFICE OF ECONOMIC ANALYSIS STUDY

A study (reference (d)) by the Office of Economic Analysis of the Department of the Interior was an important input for the decision to terminate helium purchases. The study concluded that no additional storage is required to meet federal agency needs. Present storage, additional storage from Bureau of Mines plants through 1983, and proved and probable helium-rich nonfuel reserves could provide a supply which would satisfy federal agency requirements for well over one hundred years.

P O L I C Y A S S U M P T I O N 2

STORED HELIUM AVAILABLE TO TOTAL MARKET

CURRENT SITUATION

Current production capacity for helium is 0.108 billion cubic meters (3.8 billion cubic feet) per year, which is approximately five times current demand, and is from plants which extract helium from helium-rich natural gas containing concentrations greater than 0.3 percent. Since the cessation of helium purchases by the Bureau of Mines, between 56 and 85 million cubic meters (2 and 3 billion cubic feet) of helium per year is being lost to the atmosphere. Supply from current plants will decrease as natural gas is used for fuel. When supply is unable to meet demand, supply alternatives will be to construct new extraction plants to extract helium from natural gas streams containing only 0.2 or 0.1 percent concentrations, to import helium, to use helium stored in the federal conservation program, or finally, to extract helium from the atmosphere. The course which will be taken will be determined to a large extent by the management policy maintained in the Federal Helium Program.

The total market for United States helium from 1967 to 1975 is shown in Table III. Exports supplied by private industry are included. The relatively high Bureau of Mines sales to federal agencies in the late 60's was due to the requirements of the space program. The Bureau of Mines

continues to produce more helium than it sells with the excess being added to inventory and long term conservation storage. Sales by private producers are increasing steadily to meet the increasing demand from the private sector of the economy. The private production capability far exceeds demand at the present time.

TABLE III
HELIUM MARKET FROM 1967 TO 1975
(Taken from reference (b))

Millions of Cubic Meters (Millions of Cubic Feet)

Year	Demand	Sales by Private Producers	Sales by the Bureau of Mines	Bureau of Mines Production
1967	26.1 (922)	5.7 (203)	20.4 (719)	21.8 (769)
1968	26.3 (929)	11.2 (395)	15.1 (534)	20.2 (713)
1969	23.8 (840)	11.0 (390)	12.8 (450)	19.1 (673)
1970	19.1 (675)	11.4 (402)	7.7 (273)	18.3 (645)
1971	17.0 (602)	11.6 (409)	5.4 (193)	18.9 (666)
1972	16.4 (580)	11.7 (414)	4.7 (166)	16.8 (593)
1973	18.1 (640)	13.0 (461)	5.1 (179)	8.7 (306)
1974	18.8 (665)	14.1 (497)	4.7 (168)	8.7 (308)
1975	19.8 (700)	14.9 (528)	4.9 (172)	9.5 (336)

SUPPLY AND DEMAND THROUGH 2000

Demand for conventional uses is expected to increase at a constant rate from its present level until the year 2000. Supply capability from present facilities will decrease steadily from about five times the current demand as the helium-rich natural gas fields are depleted. The crossover point where supply equals demand is expected to occur about 1990 (see figure 1). It appears that in-place extraction plants supplying helium from helium-rich natural gas streams will adequately supply the nation's requirements until about 1990. Beyond 1990, the supply will have to be supplemented by other sources.

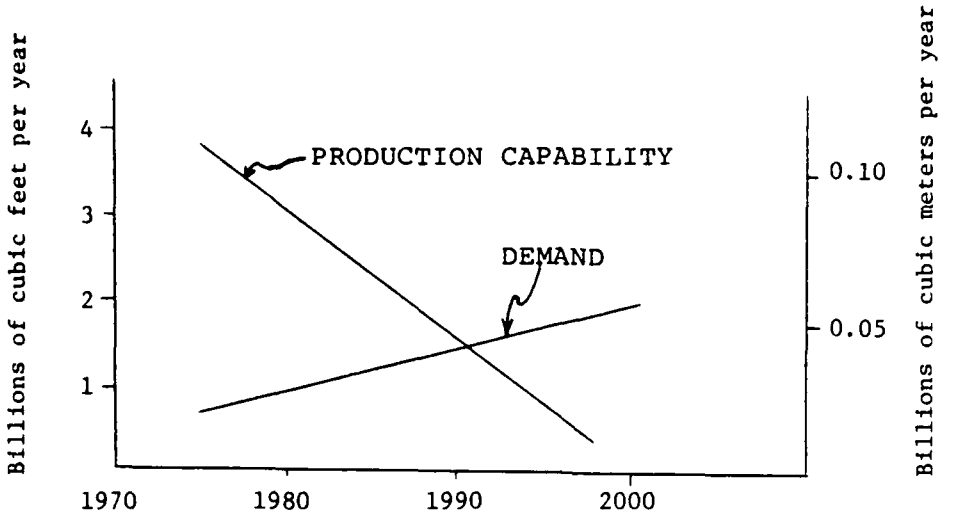

Figure 1. Projected Supply & Demand of Helium Up To The Year 2000

SUPPLY AND DEMAND BEYOND 2000

Beyond the year 2000 the constantly increasing rate of demand may be accelerated by requirements for developing energy technologies. Figure 2 presents the cumulative demand prediction for an average of the two Project Independence scenarios of the Federal Energy Adminstration considered in reference (e), and compares the cumulative demand with the proved and probable non-depleting reserves of helium. An average value is assumed for the probable non-depleting reserves. No private storage, no extraction from helium-lean natural gas streams, no additional action to conserve presently available supplies, and no imports are assumed. The curve projects that there will be sufficient helium readily available to satisfy all national helium needs until approximately the year 2023. The addition of the LTA helium requirement projection illustrates that the introduction of LTA vehicles would have a very minor effect on the supply and demand of helium. It appears that the LTA requirement would cause the available helium to be depleted only one year earlier.

MANAGEMENT POLICY ALTERNATIVES

Reference (f) discusses a detailed study of the total market situation considering the supply and demand of helium. Many assumptions were necessarily required. Many unknowns remain such as future helium discoveries and the development of technologies requiring large amounts of helium. A number of the possible management alternatives for the Federal Helium Program were considered. The various alternatives and the resulting years by which the helium stockpile would be depleted are given in Table IV. It can be seen that the management policy followed will have a significant effect on the time of stockpile depletion. Also, a decision to resume helium purchases from private producers could move the depletion date farther into the future by ten years or more.

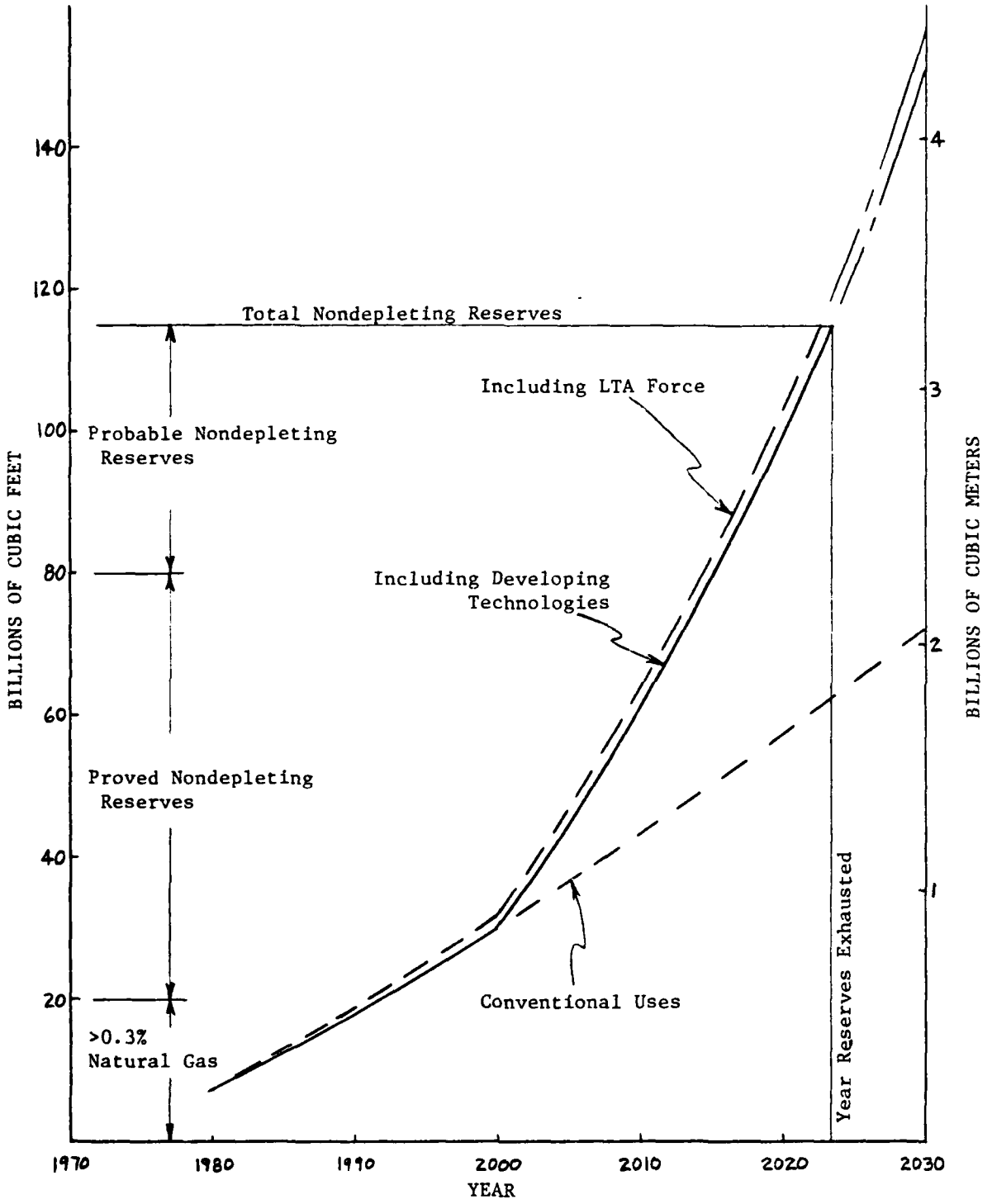

Figure 2. Cumulative Helium Inventory and Projected Use

TABLE IV
MANAGEMENT POLICY ALTERNATIVES

Policy Alternative	Approximate Year of Stockpile Depletion
Sell the conservation helium as quickly as possible by pricing the stored helium so low as to get a complete monopoly.	2001
Maintain the price of helium at $1236 per thousand cubic meters ($35 per thousand cubic feet).	2003
Maintain a price umbrella over existing helium production in the private sector, but price the conservation helium so as to discourage new construction of new extraction plants until the stockpile is exhausted.	2013
Withdraw from private market until 1987, and then begin auctioning helium so as to take 50% of the previous year's private market.	2024
Encourage construction of new plants on fuel gas streams with 0.2% helium, but price the stockpile so that plants are not built on streams of lesser concentration, and use the stockpile when the 0.2% streams are depleted.	2035
Withdraw from private market until 1987, and then begin auctioning helium so as to take 25% of the previous year's private market.	2040
Encourage construction of new plants on fuel gas streams with 0.1% helium, and use the stockpile when these streams are depleted.	2053
Conserve the helium until all other sources except the atmosphere have been exhausted.	2060+

CONCLUSIONS

1. Helium is a depleting natural resource. Unless there are significant new discoveries of helium, at some time in the future helium requirements will have to be met by extraction from the atmosphere at many times the cost of present extraction from natural gas.

2. The future supply of helium will be influenced greatly by the management policy maintained for the Federal Helium Program.

3. If the Department of the Interior is responsible to provide helium for only essential government activities, the government's presently stored helium should last for over one hundred years.

4. If it is decided to use the government's stored helium for priority uses of private industry also after 1990, the helium supply could be depleted by the year 2025.

5. It is not practical at the present time to determine exactly how the government's helium supply will be allocated beyond the year 2000 when the helium rich natural gas streams have been depleted.

6. A buildup of a large LTA vehicles force will have a very small impact on the projected supply-and-demand of helium.

RECOMMENDATIONS

1. Concept evaluation and development of the first-generation lighter-than-air vehicles for the 1980-2000 time period should proceed under the assumption that there will be an adequate helium supply.

2. If it becomes apparent that a continuing program will exist for lighter-than-air vehicles, the Navy's helium requirement should be updated for the Department of the Interior.

3. The present policy which allows large amounts of helium to be lost to the atmosphere every year should be seriously scrutinized.

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(b) Report to the Congress on Matters Contained in the Helium Act (Public Law 86-777), Fiscal Year 1975, The Secretary of the Interior, October 1975.

(c) Memorandum from the Assistant Secretary of the Navy (Installations and Logistics) to the Assistant Secretary of Defense (Installations and Logistics), Serial Number MAT 0242/LEG, 9 May 1975.

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(e) The Energy Related Applications of Helium, A Report to the President and the Congress of the United States, submitted by Dr. Robert C. Seamans, U.S. Energy Research and Development Administration, Report No. ERDA-13, April 11, 1975.

(f) Charles Laverick, Helium--Its Storage and Use in Future Years, Preliminary Report, Argonne National Laboratory, Report No. ANL/EE-75-1, November 1974.

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